Groundwater Identification using the Resistivity Geoelectric Method in Plalangan Village, Kalisat Subdistrict, Jember

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Abstract: Water is a source of basic needs that is needed by all living things including humans. Palalangan Village, Kalisat Subdistrict is one of the areas that often experiences drought during the dry season, resulting in a water crisis that will hamper the daily activities of the population. The purpose of this study is to determine the subsurface lithological structure based on rock resistivity values and groundwater potential using the resistivity geoelectric method in Palalangan Village, Kalisat District. The research was conducted experimentally in the field using the Wenner-Schlumberger configuration resistivity geoelectric method to obtain primary data in the form of field measurement data and collect relevant literature studies to obtain secondary data. The results showed that the subsurface lithologic structure of each section is different, consisting of groundwater, sandstone, clay, passive silt, gravel, sand, and dry gravel. The potential for groundwater with a considerable amount is found in section 5 which is thought to contain groundwater material with a resistivity value of 6.05 Ωm - 25.7 Ωm at a depth of 1 m and 13.8 m. This is also supported by the condition of the research area, where cross section 5 is near a resident's well which may contain a collection of aquifers below the ground surface.

Keywords: Geoelectric; Groundwater; Wenner-Schlumberger

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http://dx.doi.org/10.12962/j24604682.v20i3.20281
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I. INTRODUCTION

Water is needed by living things, especially humans although water is the most massive composition on earth (around 70%), only 0.70% can use by humans, both in the form of groundwater and surface water [1]. Various sectors of life that utilizing water both from basic household needs, industry and agriculture. It cannot be denied that water is very important for daily needs, consequently over time this water demand will be directly proportional to the increasing population [2]. If done excessively without an alternative solution to explore the potential of water, it will result in a decrease in the quantity and quality of the water [3]. Based on the condition, to meet the need for clean water potential, it can utilize subsurface water (groundwater). The availability of groundwater has considerable potential and can also be found in almost every place [4].

Groundwater is usually located at various depths depending on the local geology. Generally, the presence of groundwater is located in the aquifer layer that has a certain lithology [5]. Subsurface rock layers that hold water and can be penetrated by water are known as aquifers. Aquifers are grouped into free aquifers containing phreatic (shallow) groundwater and depressed aquifers containing artesian (deep) groundwater [6]. Exploring the presence of groundwater itself can be done by the resistivity geoelectric method [7]. The geoelectric resistivity method is a physical method that uses the properties of resistivity to determine conditions beneath the earth's surface [8].The working principle of this method is by utilizing electricity injected into the ground through 2 current electrodes (C1 and C2), then the voltage that occurs is measured through 2 potential electrodes (P1 and P2) stuck on the ground surface [9]. The resistivity geoelectric method has advantages in efficiency in data acquisition and is also easy to use during fieldwork because this method can be done without drilling which can damage the nature of soil or rock. The geoelectric resistivity method is a physical method that uses the properties of resistivity to determine conditions beneath the earth's surface. The rock resistivity values according to [10] are shown in Table I.

TABLE I: Resistivity Values of Rocks.

No	Materials	Resistivity (Ωm)
1	Graund water	0.5-300
2	Sandy silt soil	15-150
3	Clay	1-100
4	Gravel	100-600
5	Sands	1-1000
6	Sand and Gravel	100-1000
7	Dry gravel	600-1000
8	Sandstone	200-8000

The configuration used to measure resistivity is of various types, where resistivity itself is one of the geophysical tech-

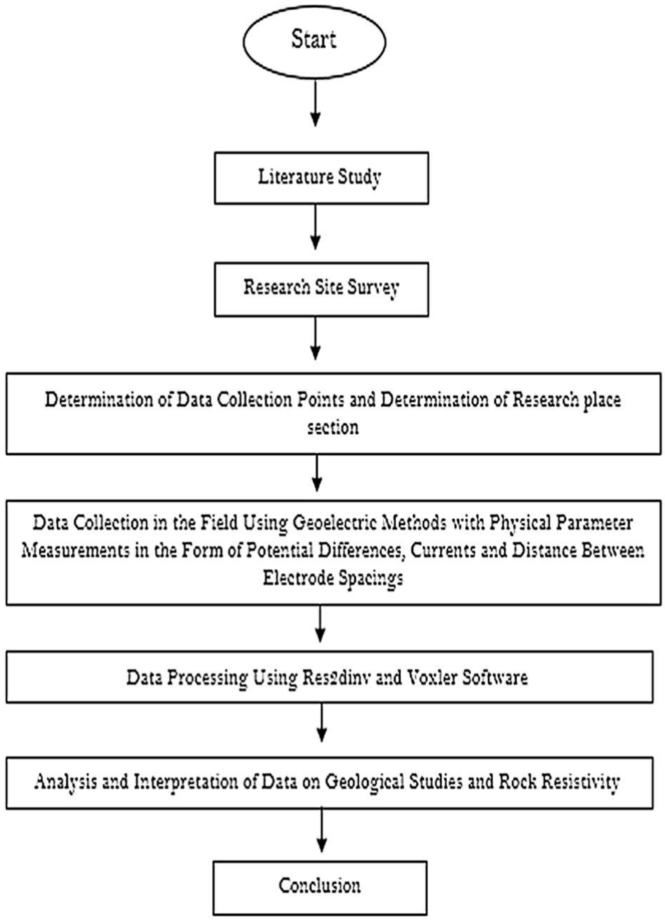


FIG. 1: Research design.

niques that examines the type of electricity that flows in the earth. This applies to the measurement of potential and current that occurs naturally, artificially, or as a result of the injection of current flow into the earth so that the resistivity method can be used to identify groundwater content or aquifer layers and know the subsoil at a certain depth [11]. The types of configurations include the wenner configuration, schlumberger configuration, dipole-dipole configuration and other types. There is also a combination of the wenner-schlumberger configuration, where this configuration has an advantage in the level of sensitivity to the influence of nonhomogeneity of an object in the subsurface laterally (horizontally) or vertically and good resolution so that with this advantage it is very appropriate to be used in identifying the potential of groundwater [12]. The result of the value of electric current (I) and the measured potential difference will obtain the apparent resistivity value (ρ_a) [13]. In addition, this configuration is very suitable for depth surveys.

The research took data in the residential area of Plalangan Village, Kalisat Subdistrict, Jember Regency because this area experiences a decrease in water discharge in relatively shallow wells during the dry season so that it experiences drought, and the increasing number of residential areas in the area will certainly increase the need for clean water. One alternative to meet the need for clean water in the area is to utilize groundwater. Therefore, this study was conducted to analyze the subsurface lithological structure based on the resistivity value and the presence of groundwater potential in the study area using the Wenner-Shcumberger configuration resistivity geoelectric method. This configuration has the advantage of having a high level of sensitivity to the influence of nonhomogeneities that exist in the subsurface of the earth in mapping and sounding, and also has excellent vertical resolution and deep current penetration [14]. From these advantages, it is very much utilized in identifying subsurface lithological structures, including the estimation of groundwater potential.

II. DESIGN AND METHOD

The type of research used is descriptive quantitative with the research design used is a direct field survey and the data collection stage uses interview techniques with local residents, data acquisition is carried out experimentally in the field using the Wenner-Schlumberger configuration resistivity geoelectric method to obtain primary data in the form of data measurement results in the field and collect relevant literature studies to obtain secondary data. This resistivity geoelectric method can be used to determine the groundwater content or aquifer layer and can also determine the subsurface lithological structure at a certain depth by injecting DC electric current on the earth's surface through two current electrodes and two potential electrodes stuck on the ground surface. Data collection was carried out as many as 5 place sections with the length of each section 60 m, the distance between sections 5 m and the spacing between electrodes 4 m. Each section has 16 measurement points with each electrode 4 m long and the main data used is 45 where this main data is the amount of data used during research. Each section has 16 measurement points with 5 repetitions. The data obtained is then processed using Res2dinv software for 2D (two dimensional) modeling and Voxler software for 3-dimensional modeling. Res2Dinv is software that can interpolate and interpret prospecting field data from geophysical methods. The basic equation used in 2D resistivity inversion is generally the forward modeling equation. This equation relates model parameters such as rock resistivity values that are linked to observational data, such as the apparent resistivity value. Mathematically, it can be written using the Wenner-Schlumberger configuration equation as follows:

$$\rho_a = K\frac{\Delta V}{I} \tag{1}$$

$$\rho_a = \pi n(n+1)a\frac{\Delta V}{I} \tag{2}$$

where K is the geometry value, ρ_a is the apparent resistivity value, I is value of electric current and ΔV is potential difference. Determination of subsurface constituent rocks can be done by correlating with Table **??**tab1. Resistivity Values of Rocks, geological data and also relevant research. The research design is shown in Fig. 1. The geological map and points of the research area are shown in Fig. 2 and Fig. 3.

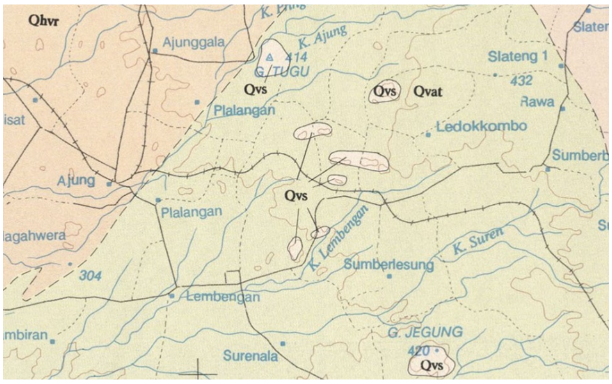
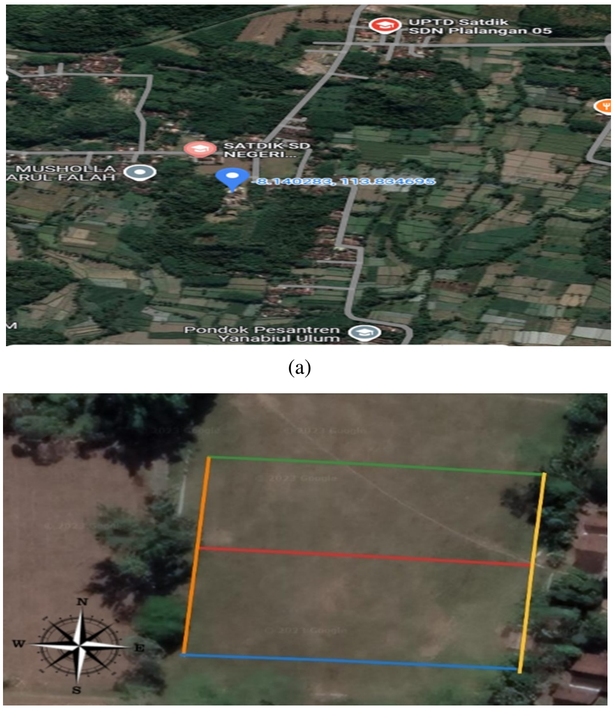


FIG. 2: Geological map.



(a)

(b)

FIG. 3: Research Location.

III. RESULTS AND DISCUSSION

Based on the research that has been done by taking data using the resistivity geoelectric method, the Wenner-Schlumberger configuration produces data in the form of current values (I) and potential difference values (V) which are then processed using Microsoft Excel to obtain datum point values, geometry factors (K), resistance (R) and apparent resistivity (ρ_a). The next step is to process the data using Res2dinv software to present the subsurface structure with (2D) modeling that displays different color images, depths, conductivity values and resistivity values. Furthermore, depth, position in distance and resistivity value are used to create 3-dimensional (3D) modeling, which is carried out using Voxler software with the x value is the datum point. The following is a (2D) modeling display using Res2dinv software on place section 1 to place section 5:

A. First place section

The first section is located at coordinates 8°8'20.11 "S - 113°50'6.58 "E to 8°8'22.06 "S - 113°50'6.5 "E which leads vertically from the south towards the north with a perpendicular ground plane at an altitude of 297 meters above sea level with a total of 45 main data. On this section groundwater with a resistivity value of 4.05 Ωm - 16.3 Ωm at a depth of 1 m to 8 m at measurement points 25 m to 35 m that showed by Fig. 4.

However, at this relatively shallow depth, it cannot be said to be groundwater, the possibility that what is detected is a type of rainwater seepage or impermeable material so that water is stagnant in it. Clay material where this type of material has small pores so that water is retained and cannot escape in it with a low resistivity value of 32.6 Ωm - 65.4 Ωm at a depth of 1 m to 13.8 m at measurement points 22 m to 54 m. The type of clay material has a high porosity level than sand or gravel material but has a lower conductivity value [15]. Passive silt soil material according to [16] Passive silt soil is a soil that has a fine to coarse sandy texture with a sand content of 70%, the rest consists of silt and a little clay seen from the resistivity value obtained of 131 Ωm at a depth of 1 m to 12 m at measurement points 19 m to 25 m and a depth of 1 m to 5.41m at measurement points 38 m to 51 m. Gravel and sandstone material that has a high level of permeability so that it cannot store water with a resistivity value of 263 Ωm - 576 Ωm at a depth of 1 m to 9 m at measurement points 6 m to 19 m and at a depth of 1 m to 4 m at measurement points 43 m to 50 m.

B. Second place section

The second place section is located at coordinates 8°8'22.13 "S - 113°50'8.45 "E to 8°8'21.59 "S - 113°50'6.47 "E which leads horizontally from the west towards the east with a perpendicular ground plane at an altitude of 300 meters above sea level with a total of 45 main data. On this section groundwater with a resistivity value of 9.83 Ωm - 32.6 Ωm at a depth of 1 m to 13.8 m at measurement points 25 m to 54 m that showed by Fig. 5.

However, this potential groundwater still cannot be used as a clean water reserve due to its limited amount. Contain passive silt soil material with a resistivity value of 59.5 Ωm - 108 Ωm at a depth of 1 m to 13.8 m at measurement points 13 m to 29 m and at a depth of 1 m to 7.95 m at measurement points 34 m to 55 m. Passive silt soil material with a resistivity value of 59.5 Ωm - 108 Ωm at a depth of 1 m to 13.8 m at measuring points 13 m to 29 m and at a depth of 1 m to 7.95 m at measuring points 34 m to 55 m. Contain sand material with a medium resistivity value of 197 Ωm at a depth of 1 m to 12 m at measurement points 10 m to 23 m. Sandstone and dry gravel material with a high resistivity value of 360 Ωm - 655

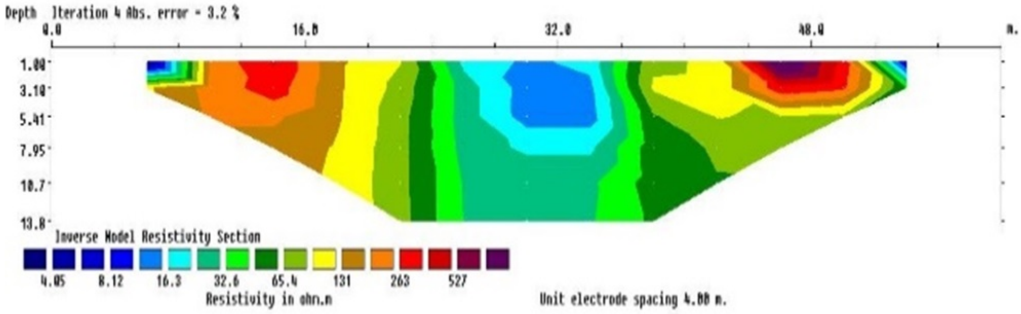


FIG. 4: Distribution of Resistivity Values of place section 1.

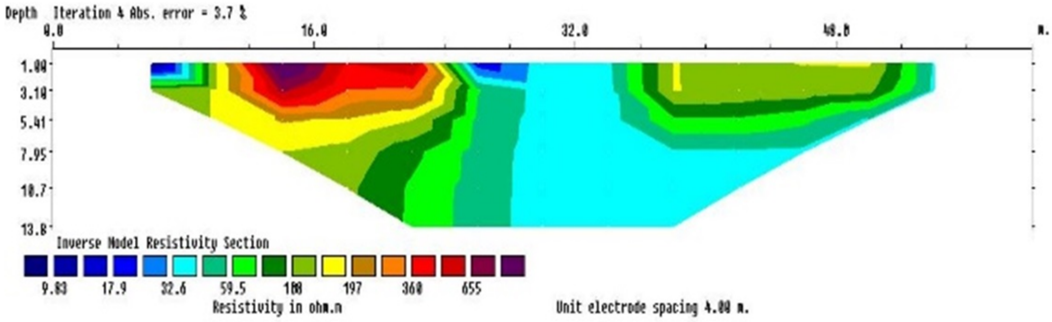


FIG. 5: Distribution of Resistivity Values of place section 2.

Ωm at a depth of 1 m to 9 m at measurement points 11 m to 23 m. The type of gravel or dry gravel material has a relatively high hydraulic conductivity value and sandstone is a type of rock that has a medium conductivity value [15]. The greater the hydraulic conductivity value of a material, the greater the porosity of the material so that it is able to pass water and is difficult to be electrified, which causes the resistivity value obtained to be greater.

C. Third place section

The third place section is at coordinates 8°8'22.27 "S - 113°50'8.34 "E to 8°8'24.4 "S - 113°46'27.73 "E which leads horizontally from the west at an altitude of 281 meters above sea level towards the east at an altitude of 276 meters above sea level so that the ground plane on this section is more sloping towards the east using the main data with a total of 45 main data. On this section groundwater with a resistivity value of 8.27 Ωm - 28.2 Ωm at a depth of 1 m to 7.95 m at measurement points 32 m to 55 m, possibly detected seepage or residual rainwater trapped in the soil. Contain passive silt soil material with a resistivity value of 52.2 Ωm - 96.4 Ωm at a depth of 1 m to 3.10 m at measurement point 8 m and at a depth of 1 m to 13.8 m at measurement points 30 m to 45 m. Sand material with a medium resistivity value of 176 Ωm at a depth of 1 m to 5.41 m at the 10 m measurement point and at a depth of 1 m to 13.8 m at the 26 m measurement point. Contain dry sandstone and gravel material with a high resistivity value of 329 Ωm - 609 Ωm at a depth of 1 m to 13.8 m at measurement points 8 m to 28 m.

This type of material has a very high level of permeability compared to sand with rock pores that are large enough to pass water and the ability to precipitate water is less likely than sand material. The availability of groundwater is at the middle measurement point to the final measurement point where water is detected to tend to move from west to east, this is seen from the topography of the third section which has a landform that tends to slope to the east where the western area has a greater height level than the eastern area.

D. Fourth place section

The fourth place section is at coordinates 8°8'22.49 "S - 113°50'8.05 "E to 8°8'20.9 "S - 113°50'8.09 "E which leads horizontally from the west towards the east with a perpendicular ground plane at an altitude of 295 meters above sea level with a total of 45 main data. On this section groundwater with a resistivity value of 4.78 Ωm - 16.1 Ωm at a depth of 1 m to 3.10 m at measurement points 6 m to 9 m and at a depth of 1 m to 5 m at measurement points and 17 m to 54 m. Groundwater on this section is along the measurement point but this cannot be said to be groundwater because of the relatively shallow depth and is on the surface of the ground, the possibility that is detected is seepage or residual rainwater stagnant in the soil. Contain clay material with a low resistivity value of 29.6 Ωm - 54.3 Ωm at a depth of 1 m to 10.7 m at measurement points 8 m to 51 m.

According to [17], the type of clay material has a slower

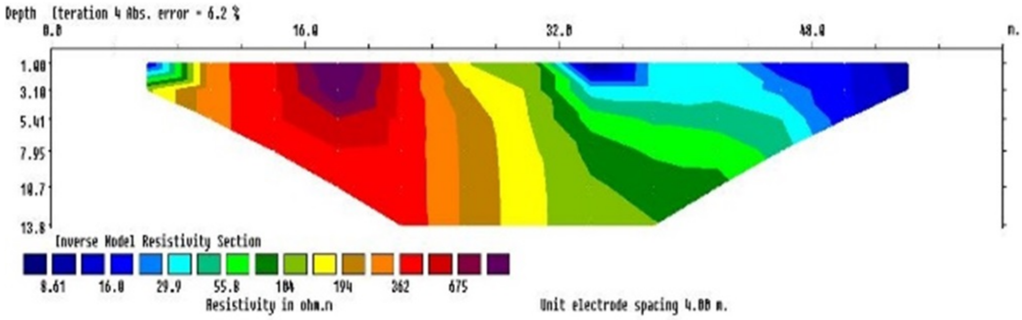


FIG. 6: Distribution of Resistivity Values of place section 3.

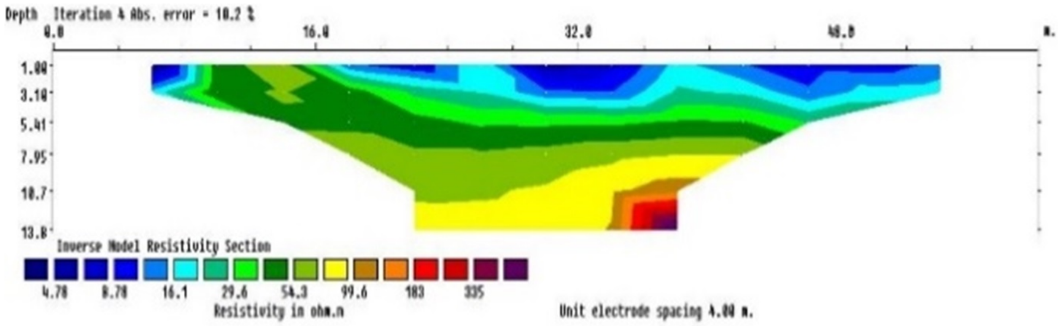


FIG. 7: Distribution of Resistivity Values of place section 4.

permeability rate than passive silt soil in passing water because the clay structure is quite dense. Passive silt soil material which has a conductivity value that is still relatively low because it is mixed between soft and passive silt, possibly small pores so that it is impermeable to water with a medium resistivity value of 99.6 Ωm at a depth of 7.95 m to 13.8 m at measurement points 22 m to 42 m. Sand and gravel material with a high resistivity value of 183 Ωm - 335 Ωm at a depth of 10.7 m to 13.8 m at measurement points 33 m to 39 m. This type of rock is classified as having a very high permeability and low porosity so that it can pass water and a relatively small waterproof ability. This type of rock is classified with a very high level of permeability and low porosity so that it can pass water and a relatively small waterproof ability.

E. Fifth place section

The fifth place section is at coordinates 8°8'22.36 "S - 113°50'8.74 "E to 8°8'20.08 "S - 113°50'6.83 "E which leads vertically from the north towards the south with a perpendicular land plane at an altitude of 295 meters above sea level with a total of 45 main data. Fig. 4 shows the results of the distribution of resistivity values on place section 5 with a maximum depth of 13.8 m, 4 iterations and an error value of 7.5% resistivity values range from 6.05 Ωm to 955 Ωm.

On this section groundwater with resistivity values of 6.05 Ωm - 25.7 Ωm at depths of 1 m to 3 m at measurement points 5 m to 16 m and at depths of 1 m to 13.8 m at measurement points and 33 m to 54 m. In terms of depth, this area is suspected to be a free aquifer containing phreatic or shallow groundwater. According to [6], groundwater from free aquifers is often found at depths of less than 40 meters below the surface. In this fifth pass, the groundwater potential has a relatively large amount seen from the blue color density generated through data interpretation and according to [18], the more intense the blue color produced, the more groundwater content in the area and vice versa. Contain passive silt soil material with a low resistivity value of 53.0 Ωm - 109 Ωm at a depth of 1 m to 13.8 m at measurement points 6 m to 53 m. Gravel material with a medium resistivity value of 225 Ωm at a depth of 1 m to 4 m at measurement points 26 m to 52 m. Contain dry sandstone and gravel material with a high resistivity value of 464 Ωm - 955 Ωm at a depth of 1 m to 3.10 m at measurement points 29 m to 52 m. This type of material has a very high permeability rate and a very low water precipitation rate so that the resulting resistivity value is very large compared to rock types that have smaller porosity.

From the five sections, each section has a different and constant height, but section 3 has a significant height so that there is a slope seen from the topographic display with a maximum height of 281 meters above sea level and a minimum height of 276 meters above sea level, this section is the lowest section of the other sections so that it causes a slope area.

The slope area leads from the west towards the east, which is likely the movement of water from the western upstream

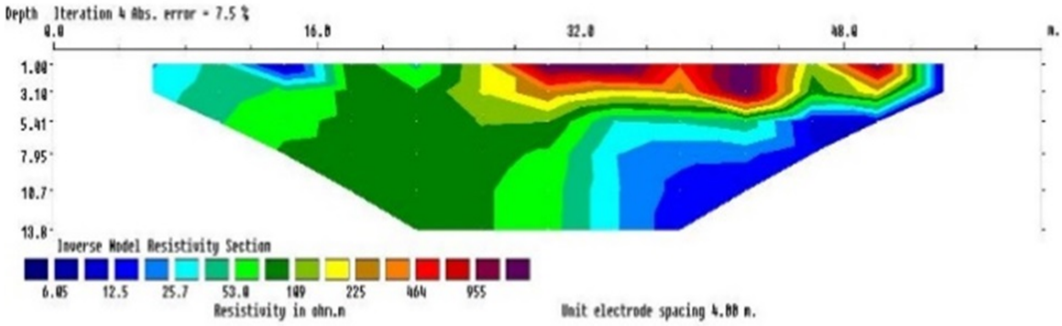


FIG. 8: Distribution of Resistivity Values of place section 5.

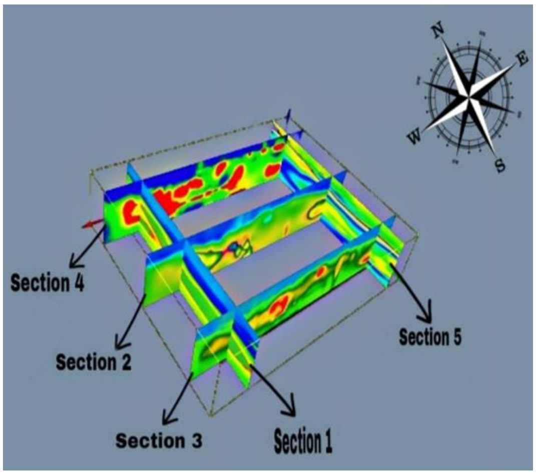


FIG. 9: Cross section of each section with the Obliquelimage.

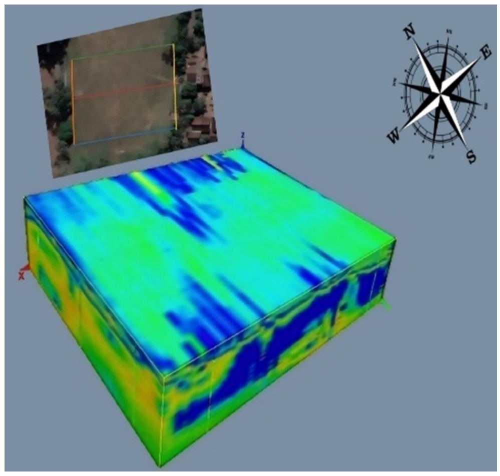


FIG. 10: Cross section of each section with the VolRender.

to the eastern downstream, thus showing conformity with the results of the 2D cross section on section 5 which detected a lot of groundwater. It is suspected that Section 5 is a gathering place or groundwater flow from Section 3 that leads to Section 5.

The results of data processing using Res2dinv followed by visualization of 3-dimensional (3D) modeling using voxler are shown in the following Fig. 9 and Fig. 10.

Based on the results of data processing using voxler which is the result of correlation from 2D modeling using Res2dinv, it is used to visualize the cross-sectional shape and detection of groundwater in the study area with 3-dimensional modeling. In Fig. 9 is the shape of the cross section of each section with the Obliquelimage feature showing intersecting each other, this feature produces realistic images and looks more clearly each rock constituent of each section. In Fig. 10, the cross section of each section with the VolRender feature shows the entire section with a solid volume shape, this feature provides a comprehensive but less detailed image. In Section 1 contains groundwater, clay, passive silt soil and gravel and sandstone materials. Section 2 contains groundwater, silt, sand, sandstone and dry gravel. Section 3 contains groundwater material, passive silt soil, sand and dry sandstone and gravel. Section 4 contains groundwater, clay, sandy silt soil and sand and gravel. Section 5 contains groundwater, passive silt soil, gravel and dry sandstone and gravel. The results of research and data interpretation that have been carried out, in terms of vertical direction, section 1 is at a greater altitude than section 5, while horizontally section 2 has a greater altitude than section 4 and section 3, and section 4 is higher than section 3 so that the research area is known to have a slope area that tends to slope towards the south which causes water to flow southward. The slope area has a considerable influence on the motion of water flow where water flows from a high place to a low place due to the gravitational pull of the earth. It is known that section 5 has a relatively large amount of potential groundwater to the south of the measurement point, this can be seen from the density of the blue color produced through data interpretation. In addition, this is also supported by the condition of the research area, where Section 5 is the section closest to the local residents' wells, it is possible that the area has a collection of aquifers below the ground surface. The subsurface lithological structure of the study area varies so that the types of soil detected from section 1 to section 5 are also different. section 1, section 2, section 4 and section 5 are known to contain typic Eutrudepts soil types while section 3 contains typic udipsamments soil type. One of the factors affecting the difference in soil types is the altitude and topography of the study area where Typic Udipsamments soil types are generally located in higher areas than Typic Eutrudepts soil types.

IV. CONCLUSION

Based on the results of the analysis that has been carried out, it can be concluded that subsurface lithologic structure based on rock resistivity values in Plalangan Kalisat Village, Jember varies greatly with each pass. According to the constituent rocks of the subsurface of the first section to the fifth section consists of groundwater material, sandstone, clay, passive silt soil, gravel, sand, and dry gravel. Based on the morphology of the research area, the classification of Typic Eutrudepts soil type is obtained which contains sedimentary rock types such as sandstone with loamy soil texture and passive loam (silt) and also obtained Typic Udipsamments soil type where this soil has a varied texture generally containing sand and gravel.

The potential for groundwater using geoelectric methods in Plalangan Kalisat Village, Jember each track exists but has limited reserves and is also located at a relatively shallow depth, while those with a large amount of groundwater potential are found on track 5 with a resistivity value of 6.05 Ωm - 25.7 Ωm at a depth of 13.8 m at measurement points 33 m to 54 m, presumably containing groundwater material that can be used as an alternative solution to the availability of clean water sources. This is judged by the density of the blue color produced through data interpretation. In addition, this is also supported by the condition of the research area, where track 5 is near a resident's well which may contain a collection of aquifers below the ground surface.

Acknowledgments

Thanks to all those who have been involved in this research so that the preparation of the journal can be completed properly.

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